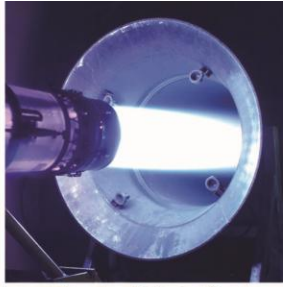
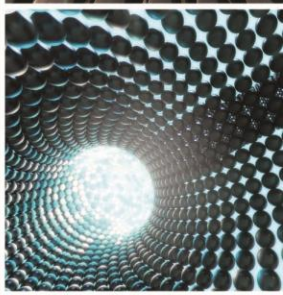
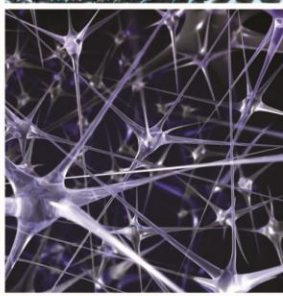
Swansea University
Prifysgol Abertawe

Advanced Structural Analysis

EGF316

Compound Cylinders




Lecture Content

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- Compound cylinders
- Shrinkage or interference allowance
- Solid shafts
- Force fits

Lamé's Equations

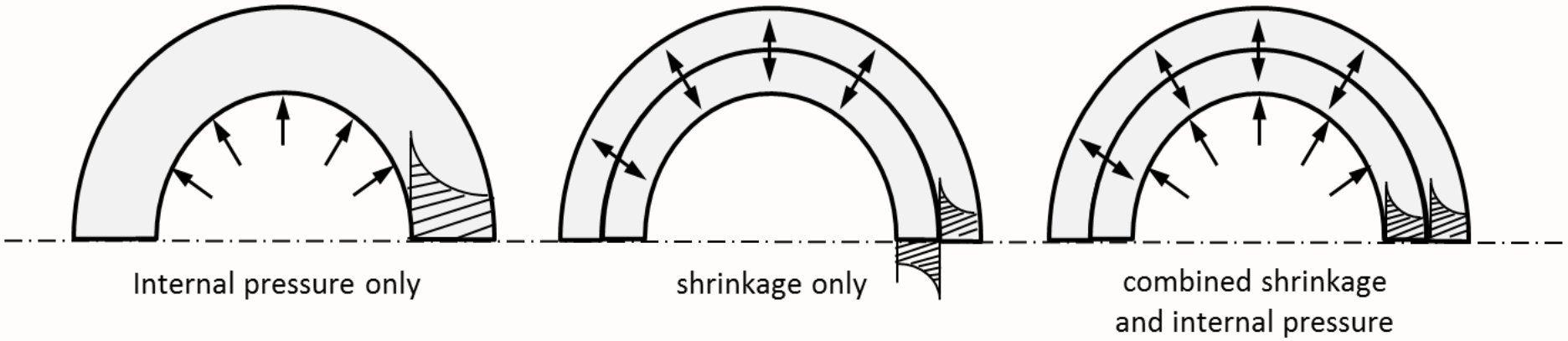
$$\sigma_r = A - \frac{B}{r^2}$$

$$\sigma_\theta = A + \frac{B}{r^2}$$

$$\sigma_L = \frac{P_i {R_i}^2 - P_o {R_o}^2}{\left({R_o}^2 - {R_i}^2\right)} = constant$$

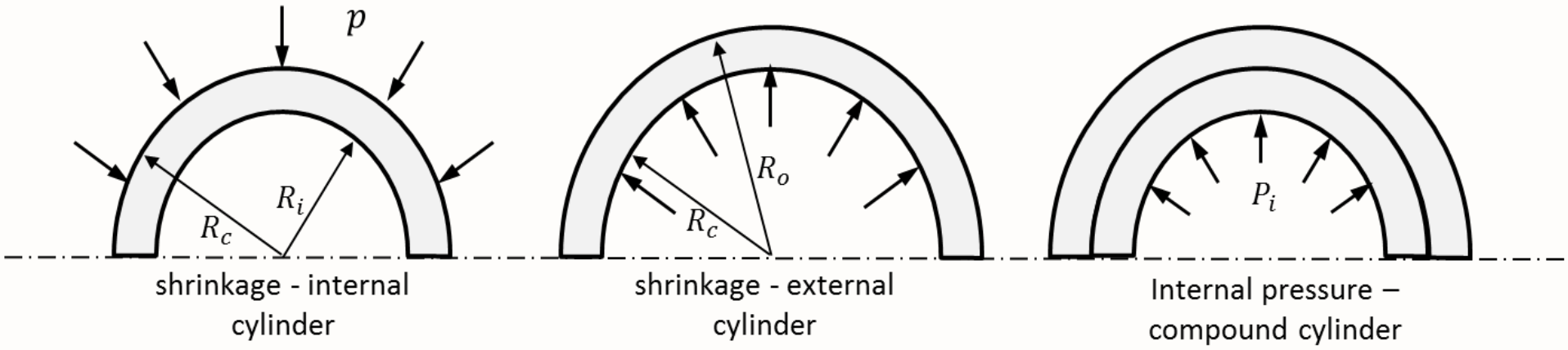
Compound Cylinders

$$\sigma_\theta = A + \frac{B}{r^2} = \frac{p_i {R_i}^2}{\left({R_o}^2 - {R_i}^2\right)}\left(\frac{r^2 + {R_o}^2}{r^2}\right)$$



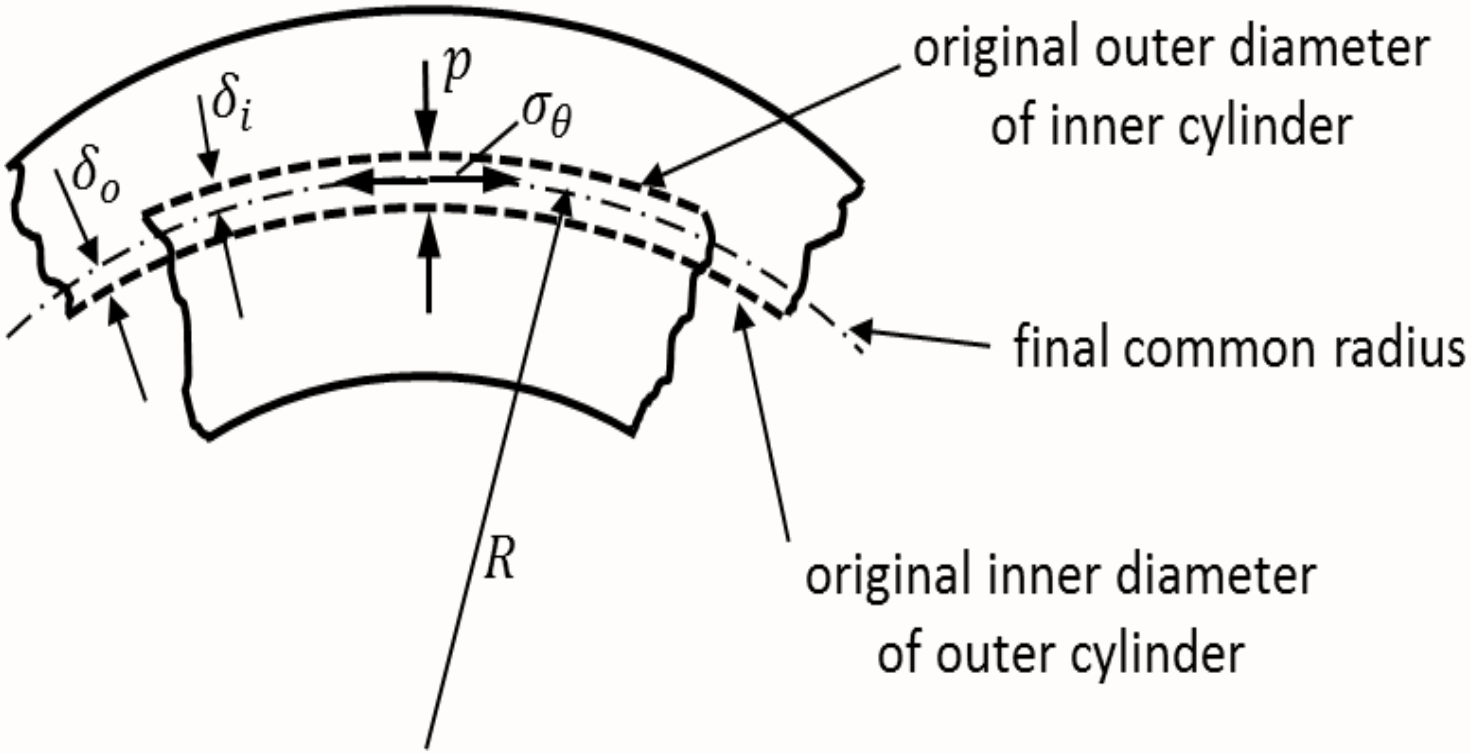
Distribution of Hoop stress for internal pressure

Compound Cylinders



Condition 1: Shrinkage pressure on the inner cylinder only
Condition 2: Shrinkage pressure on the outer cylinder only
Condition 3: Internal pressure only on the compound cylinder

Shrinkage (Interference Allowance)



Shrinkage (Interference Allowance)

$$\text{Total shrinkage} = R\left[\frac{(\sigma_{\theta_o} + v_1 p)}{E_1} - \frac{(\sigma_{\theta_i} + v_2 p)}{E_2}\right]$$

$$\text{Total shrinkage} = \frac{R}{E}(\sigma_{\theta_o} - \sigma_{\theta_i}) \quad \text{same material}$$

Example

A compound cylinder is formed by shrinking a tube of 250mm inside diameter and 300mm outside diameter onto another smaller tube of 200mm inside diameter and 250mm outside diameter (nominal dimensions). Both tubes are manufactured from steel. The interference pressure at the junction is 10MPa. If the compound cylinder is then subjected to an internal pressure of 80MPa, calculate the hoop stress distribution

Method: obtain results for shrinkage and internal pressure separately and then use superposition to combine.

Shrink fitting solid Shafts

$$\sigma_r = A - \frac{B}{r^2} \qquad \sigma_\theta = A + \frac{B}{r^2}$$

$$\sigma_r = \sigma_\theta = A$$

$$\sigma_r = -p$$

The hoop and radial stresses throughout a solid shaft are at all points constant and equal to the shrinkage or interference pressure and both are compressive.

Force Fits

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Compound cylinders can be manufactured by shrinking of force-fit methods. In the case of force-fits, the interference allowance is sufficiently small to allow the outer cylinder to be pressed (forced) over the inner cylinder with a large axial force which much be sufficient to overcome the resisting friction.

$$F = 2\pi\mu pRL$$